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Exploring ICT competency and communication preferences in higher education: insights from Croatia

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ABSTRACT

The digital transformation of education underscores the need for effective integration of information and communication technologies (ICT) in higher education. This study examines differences in ICT usage between teaching staff and students across various types of higher education institutions in Croatia, focusing on the impact of institution type and academic programs on ICT usage levels, digital competencies, and communication preferences. A quantitative research approach was employed, with data collected via a survey distributed to 70 teaching staff and 472 students using random sampling from public universities, public polytechnics, and private higher education institutions. The results reveal significant disparities in digital competencies, with students in private institutions demonstrating higher ICT usage compared to public institutions. Additionally, both groups favor synchronous communication (SC), although students display a stronger preference. These findings highlight a digital divide within academia and the need for targeted ICT training, particularly in public institutions. The study proposes measures to enhance ICT infrastructure and develop digital competencies through systematic workshops and training sessions. This research emphasizes the importance of addressing digital inequalities and improving the quality of education by integrating advanced technological solutions in higher education.

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1. INTRODUCTION

The application of new information and communication technologies (ICT) is transforming the habits and behaviors of individuals and groups, as well as the structure of the entire socio-economic community, both globally and locally. Today, compared to previous decades, communication has significantly changed and advanced. It is now quantitatively and even dominantly shaped by the global communication and transmission network, namely the internet, and particularly by its largest and most popular medium, the World Wide Web (WWW), which hosts millions of web servers and billions of web pages. Additionally, the use of ICT has led to a massive multiplication of information, with estimates suggesting that more information has been produced in the last few decades than in the previous 5,000 years. While public information and communication processes in the past relied on traditional media such as print, radio, and television, we are now becoming increasingly dependent on the internet. The internet contributes to creating an entirely new communication dimension in terms of the reception, publication, and exchange of

information. Due to its widespread nature, the internet has, in a very short time, become the most dynamic and democratic medium in the history of communication.

Considering the development of digitalization, we can say that significant progress is also evident in the field of education, particularly in higher education. Various applications and communication methods between teaching staff and students, as well as among students themselves, have considerably reduced the time it takes to disseminate information, with a much lower risk of miscommunication. Higher education institutions in Croatia and beyond are continuously working on further developing and implementing various ICT systems that simplify and streamline processes at all levels.

The study seeks to explore differences in digital competencies and communication preferences between teaching staff and students. Its objective is to offer recommendations for improving the use of technology in higher education to enhance the quality of the educational experience. The added value of this research lies in its identification of gaps in ICT usage and digital competencies between teaching staff and students across different institutions, offering actionable recommendations for improving technology integration, faculty training, and digital communication strategies in higher education.

The research begins with an introduction that outlines the objectives and the need for such a study, followed by a detailed review of relevant literature in the field of education and ICT, with a focus on higher education. Next, the research methods used are presented, leading into a detailed section on the research results, highlighting the hypotheses and explaining their confirmation or rejection. Finally, the conclusion section discusses the results, with a note on the study's limitations.

2. LITERATURE REVIEW

The abundance of printed and digital books and other publications on the topic of ICT usage highlights its indispensability in all spheres of human activity. Today, theoretical and practical knowledge in this field has reached an advanced stage, forming the foundation for managing operations in contemporary and increasingly turbulent market conditions. Some research results indicate that ICT effectively contribute to the distribution and use of knowledge in higher education institutions [1]. ICT can enhance learning outcomes through greater efficiency, accessibility, and interactive tools [2]. It is also worth noting that there is a significant digital divide among professors in higher education, depending on their personal and professional characteristics [3]. Students highly value the accessibility of information through ICT in the educational process, but they also report challenges with focus, engagement, and motivation during online learning [4]. The application of ICT in education significantly contributes to improving the quality of the educational process, increases student motivation, facilitates easier access to information, and enables student-centered learning, thereby transforming the traditional teaching model into a more dynamic and interactive approach [5]. Most students, around 75%, achieved better results using digital learning strategies compared to traditional methods [6].

Pandemic periods have significantly accelerated digital processes. Overall evaluations of the transition to online classes during the pandemic were positive, though teachers experienced challenges due to intensive technology use, with primary issues including reduced interaction with students, organizing online exams, and technical difficulties [7]. Despite the end of the COVID-19 pandemic, it is recommended to increase ICT usage in teaching and learning, with suggestions for more frequent organization of workshops and training for teaching staff, students, and administrators, focusing on pedagogical issues and management [8]. There are various emotional reactions among professors. On the one hand, ICT facilitates the development of new skills, introduces new methodological approaches, and fosters a positive attitude toward digital tools for reaching all students. On the other hand, ICT usage has increased anxiety, workload, and the need for continuous training [9].

ICT elements, including the internet, infrastructure, and learning management systems (LMS), have a positive and significant impact on ICT integration in higher education, while institutional policies have had a negative and insignificant effect [10]. The effects of ICT application in higher education institutions also vary depending on the scientific field to which the teacher belongs, with the best results observed in technical and technological sciences, as well as natural sciences and mathematics [11]. ICT can significantly assist distance education in developing countries such as India, especially in reaching tribal students, overcoming financial and geographical barriers through a student-centered approach, thus increasing the capacity, quality, and cost-effectiveness of the education system [12]. ICT integration in education has seen a steady increase since 2015, with special emphasis on new terms such as COVID, pandemic, self-efficacy, and behavior [13].

In universities in less developed countries, like Ghana, significant progress has been recognized in ICT infrastructure development, but key challenges such as insufficient funding, lack of expert staff, and weaker management support have been identified, hindering effective e-learning implementation [14]. The relationship between confidence in computer use, computer-related anxiety, and perceived enjoyment

influenced students' continuous intention to use ICT and their satisfaction [15]. ICT application in higher education has a positive impact on student performance, with these effects being more evident through indirect factors such as changes in the educational environment and teacher characteristics, while organizational structures need to be adapted to achieve better results [16]. Consequently, pedagogical practices have transformed, student engagement has improved, and educational resource availability has increased, positively impacting learning outcomes and the development of critical skills such as problem-solving and digital literacy [17]. Students have various approaches to using and creating ICT, and higher education institutions should recognize the difference between passive use of platforms and active creation of digital formats by students [18].

Students often use ICT for personal than educational purposes, and their use of ICT for informal learning is strongly associated with personal use, while use for formal learning is more influenced by the educational system than by the students themselves [19]. To address the low enrollment rate, the Indian government has introduced several measures, including the use of information technology and ICT tools such as massive open online courses (MOOCs) and study webs of active-learning for young aspiring minds (SWAYAM), to make education more accessible to broader segments of society [20]. ICT has brought significant changes in education and provides crucial support to higher education in India, enabling access to education without time and geographical constraints, improving material sharing, and fostering the development of collaborative skills, with the potential to transform and democratize education [21].

The use of ICT in education is primarily focused on areas of general education and technology, while a lack of research has been observed in areas such as autism, rural areas, inclusive education, disability, cyberbullying, indigenous rights, and social exclusion, indicating the need for further research in these topics [22]. Research results show that increased use of ICT in schools in autonomous communities has no positive effect on mathematics and reading outcomes, while a positive effect has been recorded on science outcomes. This suggests that the impact of ICT on educational outcomes depends on the subject and the way technology is used, indicating the need for careful evaluation to determine in which areas and how ICT can positively affect educational results [23]. ICT enables interactive learning, personalized options for expressing understanding, and prepares students for technological changes in society and the workplace [24]. Most professors do not use technology in teaching, but a significant increase in ICT use in educational activities has been observed after training programs, resulting in better lesson planning and greater integration of technology into the curriculum [25]. Accordingly, most professors have a positive attitude toward using ICT, but limited knowledge and understanding of technology integration in teaching are the main obstacles, emphasizing the need for greater use of computers in interactive and practical activities, and they seek support in learning how to use software and integrate ICT into teaching [26].

One of the key success factors for technology-based teaching and learning is excellent knowledge of ICT tools and workspaces by teachers, and effective teacher preparation programs have also significantly contributed to improving students' learning quality [27]. Most African countries face similar issues. The digital transformation of higher education in Cameroon encounters significant obstacles such as lack of infrastructure, limited internet access, and insufficient financial resources, while solutions include increased investment in digital infrastructure, strengthening international cooperation, and improving educational system management [28]. In Ethiopia, while there are adequate and feasible policies and strategies for promoting digitalization of higher education, the main challenges are poor internet connectivity, insufficient ICT infrastructure, lack of expert staff, and staff resistance to change, indicating that policies alone are not enough without government commitment and a focus on quality through digital transformation [29].

Digital technologies had a positive impact on the learning process of students in higher education, promoting active participation and interaction inside and outside the classroom, but their use is mainly focused on information transfer, while they are less used to promote collaborative learning and the development of cooperative skills [30]. Certain research indicates that ICT integration has been superficial and teacher-led, with ICT being seen more as a tool to increase teacher productivity than to improve student learning outcomes. The main obstacles to integration are the lack of technical support and professional development, highlighting the need to change teacher attitudes about their role in higher education [31].

Students often face challenges such as lesson duration, access to modern devices, and issues with research skills, in contrast to teachers who had a much more positive attitude toward the impact of ICT on teaching [32]. Digital technologies are mainly used to support transmissive teaching methods, allowing students individual access, sharing, and publishing information, while they are much less frequently used to promote collaborative and cooperative learning [33]. Most students expressed a willingness to use AI tools in the future, and a study showed improved functionality, user flow, and content understanding among students who used ChatGPT compared to those who relied solely on traditional search engines [34]. The transition to online learning and evaluation platforms during lockdown accelerated the digitalization of higher education but also emphasized the need for ongoing provision of technical tools and media for teachers and students to successfully participate in online classes [35]. There have been trends in transforming writing styles

(traditional vs. digital), writing conditions, and educational technology, with the shift of higher education to a digital format during the COVID-19 pandemic spurring digital writing and new forms of collaboration through digital writing, including interactive activities with additional ICT tools to optimize the educational process [36]. The COVID-19 pandemic significantly accelerated the digitalization of higher education, and universities successfully adapted to the transition to online learning and evaluation platforms. However, the need for ongoing technical support and tools was also highlighted to ensure successful work in an online environment [37]. ICT integration has significantly increased academic enthusiasm among students compared to traditional teaching methods, leading to greater interest and motivation for learning and more positive educational outcomes [38].

Key factors for ICT use among medical and health science students at Arba Minch University in Ethiopia include previous residence, ICT knowledge, formal training, current IT courses, and IT skills. Formal integration of ICT into the curriculum is recommended to help students improve technical skills useful during studies and future work [39]. The impact of ICT use on students' academic results shows that the country's development level affects this relationship, with a more pronounced negative effect in developing countries than in developed ones [40]. Although teaching staff uses technology in the educational process, its use in developing e-courses and using interactive content is limited, with the main challenges being excessive workload and the need for technical support [41]. ICT integration in the educational process increases teachers' professional competence, student motivation, and improves educational quality, but also presents challenges due to a lack of resources and outdated equipment in schools [42]. Teachers' digital accessibility competencies need to be continuously increased to ensure inclusive digital educational materials and environments, and the main challenges include the lack of standardized tools for evaluating training outcomes [43]. Students mainly use ICT applications due to the satisfaction and benefits they provide, but social support and control over technical resources are key factors for increasing their satisfaction and effectiveness in using technology [44]. Teachers' confidence in using ICT, initial preparation, and professional development related to ICT and its application in teaching practice are key predictors of successful ICT use, while school infrastructure and team innovation are not significant factors supporting teachers' ICT use in the classroom [45]. Access to ICT at home and at school, as well as the use of ICT for entertainment, positively influences ICT use for educational purposes, while socio-economic status, school climate, and teacher factors, such as interest in ICT and job satisfaction, also play a significant role [46]. Some studies indicate that the application of ICT in school management has a positive but insignificant impact on teachers' work efficiency [47]. Teacher education students in Spain and Norway recognize the concept of responsible ICT use, including issues of privacy, cyberbullying, and digital content evaluation, as separate components of professional digital competence (PDC), with a positive correlation between their perception of these concepts, although challenges arise from cultural and linguistic differences between countries [48].

Three categories of teachers have been identified based on their attitudes toward ICT use in teaching: pioneers, who have positive attitudes; followers, who hold neutral views; and resistors, who have negative attitudes [49]. Most Turkish students use ICT at a moderate level, with resource availability varying among schools; students from schools with more ICT resources possess more advanced skills, while ICT use has not significantly impacted academic results in mathematics, reading, and natural sciences [50]. Final-year university students in Costa Rica generally exhibit a positive attitude toward ICT, with pronounced cognitive and behavioral components, while the affective component is somewhat weaker [51]. Increased availability and use of ICT at school and beyond have a negative impact on students' math and science outcomes, while positive attitudes, confidence, belief in usefulness, and autonomous ICT use have a strong positive association with academic success. Additional school activities also contribute to better results [52]. ICT use can improve students' academic performance, but only if adequate digital skills and organizational approaches are developed that support innovative and collaborative use of technology in education [53]. The availability and use of ICT infrastructure in teaching has a positive, albeit limited, effect on academic success in secondary schools in Uganda's Kasese Region, with a need for better teacher training and wider access to resources to improve overall student outcomes [54]. English language teachers in Malaysia have good knowledge and a positive attitude toward ICT, but they face challenges such as a lack of technical support and time, underscoring the need for additional infrastructural and educational support [55]. Access to ICT in schools and early use of digital devices positively correlate with academic success and student motivation, while excessive internet use outside of school can negatively impact students' motivation to learn [56].

High school students perceive ICT use in learning positively, especially in terms of increasing motivation, learning new skills, and enhancing communication. However, they tend to use it more for entertainment than educational purposes, considering formal ICT training less necessary for learning efficiency [57]. Professors in Central Visayas, Philippines, have access to ICT through motivation, operational skills, and extensive use in education, with suggestions for further improvement in digital

infrastructure and professional training to support ICT integration in the educational process [58]. University teachers in Pakistan recognize the benefits of ICT use for professional development and teaching improvement but face challenges such as limited resource access, lack of training, and technical support, which limit full ICT integration into the educational process [59]. Conditions for ICT use and ease of use are key factors for successful ICT application in teaching at universities in Nigeria, while additional infrastructural support and university policies significantly improve its integration into the educational process [60]. The impact of ICT on human development in countries with varying income levels significantly contributes to human development, especially in middle- and low-income countries, where education and political stability also play crucial roles in improving quality of life [61].

Internal factors, such as perceived usefulness, ease of use, self-efficacy, attitudes, and computer-related anxiety, significantly impact the teaching staff's intention to use technology, which positively contributes to successful ICT implementation in higher education in Saudi Arabia during the COVID-19 pandemic [62]. The availability of ICT, such as computers and internet access, has a positive effect on students' academic achievements in primary schools in Indonesia, while socio-economic characteristics and population density also significantly affect students' success, especially in urban areas [63]. Results of studies in Mexico and Spain show that factors such as infrastructure, organizational support, and digital skills significantly influence the success of technology implementation in education, with larger institutions in urban areas more successfully integrating ICT into teaching processes [64]. For successful work in digital teams, emphasis is placed on trust, leadership, and communication, which are essential skills that ICT can foster among students in both learning and professional environments [65]. Psychology plays a significant role here, with personal factors dominating over other factors when making decisions about the use of digital technologies, as was particularly evident during the COVID-19 pandemic [66], [67].

3. METHOD

In this research, both secondary and primary types of research were used. For secondary data, relevant literature in the field of ICT usage in the education sector, with an emphasis on higher education, was reviewed. Based on this analysis, research hypotheses were formulated regarding the level of ICT usage between teaching staff and students in different higher education institutions, as presented in Table 1.

Table 1. Hypothesis of the study

Hypothesis	Hypothesis description
Hypothesis 1	The difference in the level of usage of modern communication devices and internet applications in the academic community for teaching and extracurricular communication is evident depending on the type of scientific-teaching institution.
Hypothesis 2	The difference in the level of usage of modern communication devices and internet applications in the academic community for teaching and extracurricular communication is evident depending on the type of study program.
Hypothesis 3	Participants in university programs show a higher level of usage of modern communication devices and internet applications for teaching and extracurricular communication compared to participants in public polytechnic programs and private higher education institutions.
Hypothesis 4	Teaching staff from all types of higher education institutions exhibit the same level of usage of modern communication devices and internet applications in teaching and extracurricular communication.
Hypothesis 5	Teaching staff from all types of higher education institutions exhibit the same level of usage of modern communication devices and internet applications in teaching and extracurricular communication, but significantly less than students from individual types of higher education institutions.

Based on the formulated hypotheses, a sample of respondents was defined to approach the collection of primary data. Respondents were selected in the Republic of Croatia through random sampling at state polytechnic institution, independent institutions for higher education, and a state university. Table 2 provides an overview of the distribution of teaching staff and students across different types of educational institutions. It displays both the total number and percentage for each group. Out of 70 staff members, 42.9% are employed at public higher education institutions, 22.9% at private higher education institutions, and 34.3% at public universities. Of the 472 students, 64.0% are enrolled in public higher education institutions, 11.9% in private higher education institutions, and 24.2% in public universities.

Table 3 presents the distribution of both teaching staff and students across different types of educational institutions and scientific fields. It shows the total number of teaching staff (70) and students (472), along with their percentages in public higher education institutions, private higher education institutions, and public universities. Among the teaching staff, 42.9% work in public higher education institutions, 22.9% in private institutions, and 34.3% in public universities. Their representation in scientific fields includes 5.7% in natural sciences, 22.9% in technical sciences, 14.3% in biotechnical sciences, and

57.1% in social sciences. Among the students, 64.0% attend public higher education institutions, 11.9% private institutions, and 24.2% public universities. In terms of scientific fields, 5.5% are studying natural sciences, 14.8% technical sciences, 14.8% biomedicine and healthcare, 11.9% biotechnical sciences, and 53.0% are in social humanities.

Table 2. Distribution of teaching staff and students by type of educational institution

Target group	Type of institution	Count	Column N (%)
Teaching staff	Total	70	100.0
	State polytechnic institution	30	42.9
	Independent institutions for higher education	16	22.9
	State university	24	34.3
Students	Total	472	100.0
	State polytechnic institution	302	64.0
	Independent institutions for higher education	56	11.9
	State university	114	24.2

Table 3. Distribution of teaching staff and students by type of institution and scientific/artistic areas

Target group	Category	Count	Column N (%)
Teaching staff	Total	70	100.0
	Public higher education institution	30	42.9
	Private higher education institution	16	22.9
	Public university	24	34.3
	Natural sciences	4	5.7
	Technical sciences	16	22.9
	Biotechnical sciences	10	14.3
	Social sciences	40	57.1
Students	Total	472	100.0
	Public higher education institution	302	64.0
	Private higher education institution	56	11.9
	Public university	114	24.2
	Natural sciences	26	5.5
	Technical sciences	70	14.8
	Biomedicine and healthcare	70	14.8
	Biotechnical sciences	56	11.9
	Social humanities	250	53.0

After analyzing the data obtained from the survey questionnaire, descriptive statistics were used to describe the basic characteristics of the sample. This method provided insight into key indicators such as the median (M), which represented the central value of ICT usage assessments, and the interquartile range (IQR), which indicated the dispersion of responses within the groups. Additionally, indicators of skewness (Skew) and kurtosis (Kurt) were used to describe the shape of the data distribution. These parameters provided essential information about how the data were distributed within the target groups, which later influenced the choice of appropriate statistical tests. To determine whether the data were normally distributed, the Kolmogorov-Smirnov test for normality was applied. Based on the results of the Kolmogorov-Smirnov test, the Kruskal-Wallis's test, a non-parametric method used to compare more than two independent groups, was employed. This test allows for the comparison of ranks between groups, making it suitable for assessing differences in ICT usage among various types of higher education institutions. The Kruskal-Wallis's test was applied separately for groups of teaching staff and students to determine if there were statistically significant differences in the perception of ICT usage volume between the groups. Specifically, the test was applied to teaching staff from State Polytechnic Institution, Independent Institutions for Higher Education, State University, as well as to students from the same types of institutions. Following this, the Mann-Whitney U test was used to compare specific pairs of groups. To assess differences in the perception of different types of communication (synchronous communication (SC) and asynchronous communication (AC)), the Chi-square test was used.

4. RESULTS AND DISCUSSION

To assess the extent of ICT usage in the teaching process and extracurricular communication in higher education institutions, a scale from 1="very low" to 5="very high" volume was used. If teaching staff or students believed that the institution did not use ICT at all in the teaching process or extracurricular communication, they had the opportunity to express this. The assessment of ICT usage, as well as the extent of its usage in higher education institutions that do use it, was expressed in percentages. The results indicate

the ubiquity of ICT in higher education institutions—100.0% of the teaching staff and 99.6% of the students perceive that higher education institutions use ICT to some extent, as shown in Table 4.

Table 4. Perception of ICT usage by teaching staff and students in different types of institutions

Target group	Type of institution	Count	Column N (%)	ICT used	ICT not used
Teaching staff	Total	70	100.0	100.0	0.0
	Public higher education institution	30	42.9	100.0	0.0
	Private higher education institution	16	22.9	100.0	0.0
	Public university	24	34.3	100.0	0.0
Students	Total	472	100.0	99.6	0.4
	Public higher education institution	302	64.0	100.0	0.0
	Private higher education institution	56	11.9	100.0	0.0
	Public university	114	24.2	98.3	1.7

The Kolmogorov-Smirnov test was applied to assess the normality of the distribution for the variable measuring the extent of ICT usage. The results in Table 5 revealed that the distribution of responses in both target groups significantly deviated from normality ($p<.05$). As a result, non-parametric methods were employed for data analysis.

Table 5. Statistical overview of ICT usage in higher education institutions for teaching staff and students

Target group	M	IQR	Skew	Skew SE	Kurt	Kurt SE	Statistic	df	K-S p
Teaching staff	3.00	1.00	0.176	0.287	-0.980	0.566	0.207	70	p<.05
Students	4.00	1.00	-0.382	0.112	0.246	0.224	0.247	472	p<.05

Legend: SE-standard error, Statistic-test result, df-degrees of freedom, K-S p-significance level of the Kolmogorov-Smirnov test.

The Kruskal-Wallis's test was conducted to examine differences in the average assessment of ICT usage in the teaching process and extracurricular communication across target groups and types of scientific-teaching institutions. The results showed no statistically significant differences in the perceived extent of ICT usage between target groups. However, statistically significant differences were observed based on the type of institution, both among teaching staff ($X^2=9.039$, df=2, $p<.05$) and students ($X^2=33.719$, df=2, $p<.05$). The Mann-Whitney U test was used to further analyze differences between pairs of institution types within each group. Among teaching staff, public university educators perceived ICT usage as significantly higher compared to their counterparts at public polytechnics ($U=194.00$, $p<.05$). Among students, those attending private higher education institutions reported significantly higher ICT usage compared to students at public universities ($U=1752.00$, $p<.05$) and public polytechnics ($U=4712.00$, $p<.05$). These findings partially support hypothesis 1, which posits that differences in ICT usage for teaching and extracurricular communication exist depending on the type of scientific-teaching institution (public polytechnics, private higher education institutions, and public universities), despite being at the same educational level. Significant differences in ICT usage were observed in both groups—teaching staff and students—based on the type of institution. While the predicted direction of the difference was confirmed for teaching staff, it was contradicted for students. Specifically, ICT usage was expected to be higher among both teaching staff and students at universities. This expectation was met for teaching staff but not for students, as students at private higher education institutions reported significantly higher ICT usage.

Statistically significant differences in the average extent of ICT usage were also identified across scientific and artistic fields for both teaching staff ($X^2=8.255$, df=3, $p<.05$) and students ($X^2=24.837$, df=4, $p<.05$). These findings support hypothesis 2, which posits that differences in the level of ICT usage for teaching and extracurricular communication exist based on the type of study program. While the differences were observed in both teaching staff and students, the expected direction of the differences was not confirmed.

Teaching staff and students were tasked with self-assessing their competencies related to ICT using a rating scale from 1="insufficient" to 5="excellent" competencies. The results of the ICT competency self-assessment were further grouped into three levels: low ICT competency (a sum of responses in the "insufficient" and "sufficient" categories), average ICT competency (corresponding to the "good" category), and high ICT competency (a sum of responses in the "very good" and "excellent" categories). Most teaching staff and students assessed their ICT competencies as high (65.7% of teaching staff and 54.4% of students). Additionally, 25.7% of teaching staff and 38.0% of students assessed their ICT competencies as average, while 8.6% of teaching staff and 7.6% of students rated their ICT competencies as low, as seen in Table 6.

The Kolmogorov-Smirnov test was used to assess the normality of the distribution for the variable measuring ICT competency self-assessment. The results in Table 7 indicated that the distribution in both target groups significantly deviated from normality (p<.05). Consequently, non-parametric methods were applied for data analysis.

Table 6. Self-assessment of ICT competencies among teaching staff and students by institution type

Target group	Type of institution	No	Column N (%)	5 (%)	4 (%)	3 (%)	2 (%)	1 (%)
Teaching staff	Total	70	100.0	20	45.7	25.7	8.6	0
	Public polytechnic	30	42.9	13.3	40	33.3	13.3	0
	Private higher education institution	16	22.9	0	75	25	0	0
	Public university	24	34.3	41.7	33.3	25	0	0
Students	Total	474	100.0	11	43.5	38	7.2	0.4
	Public polytechnic	302	63.7	6.6	48.3	37.7	7.3	0.3
	Private higher education institution	56	11.8	32.1	46.4	21.4	0	0
	Public university	116	24.5	12.1	31	46.6	8.6	0

Legend: 5–excellent, 4–very good, 3–good, 2–sufficient, 1-unsuficient.

Table 7. Descriptive parameters of the ICT competency self-assessment variable and normality distribution testing by target groups

Target group	M	IQR	Skew	Skew SE	Kurt	Kurt SE	Statistic	df	K-S p
Teaching staff	4.00	1.00	-0.345	0.287	-0.458	0.566	0.261	70	p<.05
Students	4.00	1.00	-0.142	0.112	-0.155	0.224	0.248	472	p<.05

Legend: SE-standard error, Statistic-test result, df-degrees of freedom, K-S p-significance level of the Kolmogorov-Smirnov test.

The difference in the average self-assessment of ICT competencies by target groups and the type of scientific-teaching institutions for each target group was tested using the Kruskal-Wallis's test. A statistically significant difference was found in the average self-assessment between the target groups (X^2=3.956, df=1, p<.05). The average self-assessment of ICT competencies by teaching staff was significantly higher than the average self-assessment of students. Testing the significance of the differences in average self-assessments between teaching staff and students, depending on the type of institution where they work or study, revealed a statistically significant difference only in the average self-assessment between teaching staff and students at public universities (X^2=9.991, df=1, p<.05), while no difference was found between the average self-assessments of teaching staff and students at public polytechnics and private higher education institutions. No statistically significant difference was observed in the average self-assessment of ICT competencies among teaching staff based on the type of institution they work at, but a difference was found in the student target group according to the type of institution they attend (X^2=21.987, df=2, p<.05). The difference between the medians of individual pairs of student groups was tested using the Mann-Whitney U test. Students at private higher education institutions rated their ICT competencies significantly higher compared to students at public universities (U=2036.00, p<.05) and students at public polytechnics (U=5670.00, p<.05).

The results reject hypothesis 3, which proposed that university program participants demonstrate a higher level of usage of modern communication devices and internet applications for the teaching process and extracurricular communication compared to participants in public polytechnic programs and private higher education institutions. The results show that the level of usage is higher among participants in private higher education institutions. Furthermore, the results confirm hypothesis 4, which proposed that teaching staff from all types of higher education institutions demonstrate an equal level of usage of modern communication devices and internet applications in the teaching process and extracurricular communication. Hypothesis 5, which proposed that teaching staff from all types of higher education institutions demonstrate an equal level of usage of modern communication devices and internet applications in the teaching process and extracurricular communication, but significantly less than students from individual types of higher education institutions, was partially confirmed. This difference between teaching staff and students was confirmed only for public universities, but not for public polytechnics or private higher education institutions.

In Table 8, teachers are divided in their opinions about which type of communication they see as more effective in the learning and teaching process. there were 51.4% believe that SC is of higher quality, and it is also the one they use more frequently. However, 45.7% of teachers are undecided and do not prefer either of the two types of communication, stating that neither SC nor AC stands out in terms of quality when compared. A negligible percentage of teachers (2.9%) consider AC to be of higher quality. The students'

opinions are clearer–the majority (73.8%) believe that SC is of higher quality compared to AC. Similarly to the teaching staff, the smallest percentage of students (8.9%) view AC as more effective.

The Chi-square test identified a significant difference in the distribution of communication types perceived as higher quality by the target groups (X^2=30.535, df=2, p<.05) compared to expected distributions. The proportion of teachers who believe that neither type of communication is superior to the other is significantly higher, while among students, it is significantly lower than the expected distribution. Additionally, the proportion of students who perceive SC as higher quality is significantly higher, while among teachers, it is significantly lower than expected. Furthermore, a difference was found in the distribution of communication types perceived as higher quality among students based on the type of institution (X^2=21.449, df=4, p<.05). Students at public polytechnics are significantly more likely to perceive SC as higher quality, students at public universities are significantly more likely to be undecided, while students at private higher education institutions are significantly more likely to favor AC compared to expected distributions. Hypothesis 5 was partially confirmed, where participants from all types of higher education institutions expressed a greater preference for using SC in teaching compared to AC.

Table 8. Preferences for types of communication in the learning and teaching process based on quality according to target groups and types of scientific-teaching institutions

Target group	Type of institution	No	Column N (%)	SC	N	AC
Teaching staff	Total	70	100.0	20	45.7	25.7
	Public polytechnic	30	42.9	13.3	40	33.3
	Private higher education institution	16	22.9	0	75	25
	Public university	24	34.3	41.7	33.3	25
Students	Total	474	100.0	11	43.5	38
	Public polytechnic	302	63.7	6.6	48.3	37.7
	Private higher education institution	56	11.8	32.1	46.4	21.4
	Public university	116	24.5	12.1	31	46.6

Legend: N–neither

The study by Zhao *et al*. [68] analyzes students' perceptions in China, emphasizing positive outcomes in literacy and collaboration but identifying a lack of competence in creating digital content. Compared to our study, both recognize the need for additional education and the development of digital competencies through targeted training and improved curricula [68]. A study from Spain demonstrates that teachers' perceptions of ICT efficacy and their ability to adapt to students' varying needs positively influence their attitudes and proactive behavior towards ICT integration in the educational process [69]. While it confirms the importance of positive attitudes and teacher training for successful ICT implementation, our study focuses on differences between institution types, whereas the Spanish study centers on teachers' attitudes and behavior toward technology. The study by Moreira-Choez *et al*. [70] uses advanced methods such as structural equation modeling to evaluate digital competencies among faculty, identifying key dimensions like technological literacy, access to information, and digital citizenship, emphasizing the connection between self-assessment and actual competencies, while utilizing sophisticated models for in-depth evaluation. Camacho *et al*. [25] focuses on improving faculty competencies through structured training, showing significant improvements in their ability to use digital tools while highlighting the low level of basic ICT skills among many teachers before intervention. This study centers on progress through specific training programs [25]. A study from Pakistan explores multifaceted aspects of the digital divide among teaching staff, including motivation, physical access, skills, and actual ICT usage. The study by Santos *et al*. [71] emphasizes the need for targeted training and institutional policies for developing digital competencies, providing a broader overview of teacher competencies at an international level. The study by Liesa-Orús *et al*. [72] examines teachers' perceptions of ICT's role in developing 21st-century skills such as communication, collaboration, and critical thinking. It highlights that positive teacher attitudes are crucial for the successful integration of technology into teaching and emphasizes the transformative potential of ICT for developing students' generic skills.

The review study by López-Nuñez *et al*. [73] analyzes instruments for assessing teachers' digital competencies globally, highlighting the dominance of models like DigCompEdu and TPACK, but also noting the lack of standardized evaluation tools. The study by Guillén-Gámez *et al*. [74] investigates the didactic use of ICT among Spanish university teachers, revealing that ICT usage is moderate to high across disciplines but noting significant differences between fields such as science and engineering, and arts and humanities. The Spanish study by Cabero-Almenara *et al*. [75] focuses on teachers' digital competencies using the DigCompEdu framework, revealing that most teachers have basic to intermediate levels of competence, with variations based on scientific fields and age. Sillat *et al*. [76] analyze various approaches and methods for

assessing digital competencies, highlighting the lack of standardized evaluation tools, the dominance of self-assessments, and the need for scalable methods based on frameworks like DigCompEdu, emphasizing global challenges in creating reliable and adaptable tools for assessing digital competencies. Cohen *et al*. [77] examines students' perceptions in Israel and Australia, revealing significant differences in the use of "official" resources (such as LMSs and library tools) and "non-official" digital resources (such as Wikipedia and social networks), with Israeli students more frequently using non-official resources.

5. CONCLUSION

The use of ICT in higher education has become increasingly essential in recent years, reflecting broader trends in digitalization across all sectors. As technology continues to evolve, its integration into educational environments is not only a response to the changing demands of the workforce but also an opportunity to enhance the quality and accessibility of learning experiences. This study set out to explore the differences in ICT usage among teaching staff and students, focusing on varying types of higher education institutions, and to assess the impact of these technologies on teaching and extracurricular activities.

The integration of ICT into higher education reflects global digitalization trends and offers new opportunities to enhance educational experiences. This research focuses on analyzing differences in ICT usage among teaching staff and students across various types of educational institutions in Croatia, with particular emphasis on communication preferences and digital competencies. The results indicate that students in private higher education institutions show a higher level of digital tool usage in educational activities compared to those at public universities and polytechnics, highlighting the need for additional investments in digital infrastructure within public institutions. Furthermore, students show a preference for synchronous forms of communication in teaching, confirming their inclination towards direct, interactive information exchange.

Recommendations arising from this study include increased funding for developing digital infrastructure in public institutions, organizing additional training for teaching staff, and strengthening the integration of digital competencies into educational curricula. Additionally, fostering collaborative learning methods through ICT could increase student motivation and improve the effectiveness of the educational process. Nonetheless, the study faces limitations, such as the specific context of Croatia and a relatively limited sample of institutions, which may affect the generalizability of the results. In conclusion, this study emphasizes the need for systematic improvements in ICT in education, especially within public institutions, to reduce the digital divide and ensure the quality of the educational experience aligns with the demands of the digital age. This research highlights the importance of reducing the digital divide in higher education through targeted training and the improvement of ICT infrastructure, particularly in public institutions. The results emphasize the need for systematic integration of digital competencies into curricula, which can enhance the quality of teaching, student motivation, and engagement. In the future, our findings can serve as a foundation for developing digital transformation strategies and adapting education to contemporary technological challenges.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
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P : **P**roject administration
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CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

This study involved the administration of an anonymous questionnaire and did not include any sensitive personal data or interventions with human participants. In accordance with institutional guidelines, ethical approval was not required. All procedures were conducted in line with the principles of the Helsinki Declaration.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [MŠ], upon reasonable request.

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